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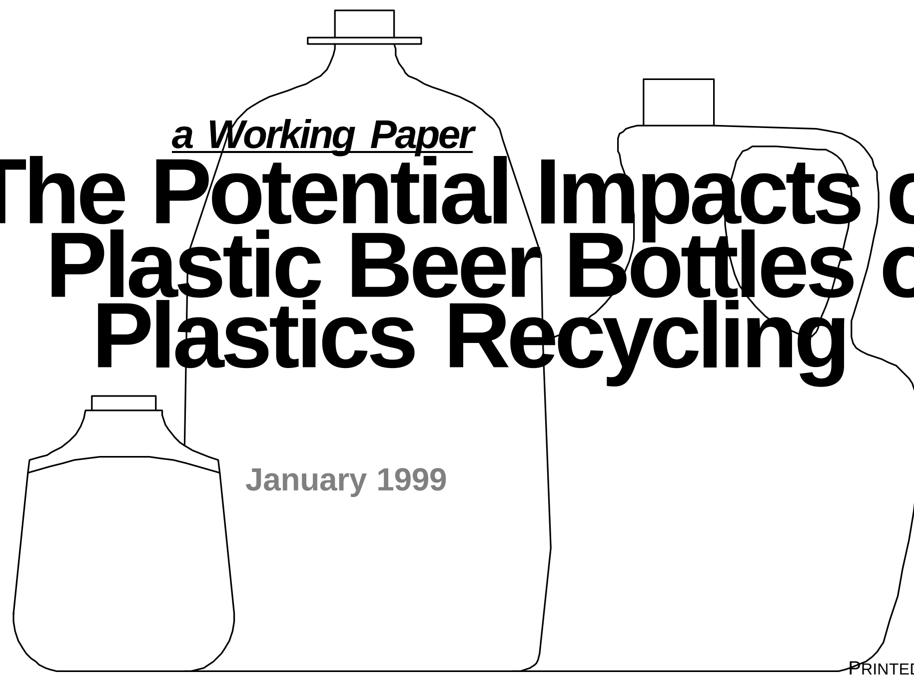
the PLASTIC REDESIGN PROJECT



a Working Paper

The Potential Impacts of Plastic Beer Bottles on Plastics Recycling

January 1999

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Introduction

On November 2, 1998, Miller Brewing Company began test marketing its product line of Miller Genuine Draft, Miller Lite and Icehouse in a newly designed plastic beer bottle in 20 ounce and one liter packages in Los Angeles, Phoenix/Tucson, Dallas/Fort Worth, San Antonio, Miami, and Norfolk (VA).

This bottle launch, based on a new design by Continental PET Technologies, represents the first large-scale distribution of beer in plastic bottles in the United States, and it is a major step towards the plastic beer bottle's widely predicted nationwide debut.

Miller's foray follows more active testing of beer in multilayer PET bottles in Europe. UK-based, Bass Brewers, using a Schmalbach-Lubeca design, is thought to have been the first with a test in 1997 in France and Spain, and at least two additional brewers — Karlsberg and Kronenbourg — tested beer in PET containers in 1998, with the Netherlands' Heineken expected to market test in 1999.

Speculation suggests that the plastic beer bottle will make major inroads displacing either glass bottles and/or aluminum cans for non-premium brands, depending upon consumer acceptance. Initial markets will target sports and recreation venues where glass or metal cannot be used, and then expand to substitute for glass and/or metal containers generally in 16 ounce and larger containers.

Less often discussed is how recyclers will react to the new designs in plastic bottles that are being considered for beer in view of the present precarious state of plastics recycling. This may be another limiting condition for new packages because, with the current mix of bottle designs and processing structures, the cost to handle recycled plastic exceeds the price of virgin resin during market downturns. That is not an economically sustainable cost picture. Any additional costs to process used plastic bottles imposed by a new design for a major application such as beer could create precipitous cost pressures on plastics recycling.

Thus, on the one hand, poorly designed bottles in significant numbers will inevitably either erode the number of communities that can afford to continue to recycle plastic, or necessitate tax increases to pay for the additional costs the new bottle imposes in those communities which decide to continue plastics recycling notwithstanding the extra costs. And even those which chose to continue will face substantial hurdles as reclamation capacity, that is not subsidized, declines and end markets recede.

> *"With the ingenuity of the design industry, we fully anticipate that an economially recyclable plastic beer bottle will be developed."*

On the other hand, a properly designed, competitively priced bottle that contemplates the recyclers' concerns would not increase recyclers' costs. Indeed, in some instances, well conceived designs might improve recyclers' overall cost picture.

That constructive branch of the fork in the road — the one which also considers the back end of the product cycle — would overcome a major impediment to ready acceptance for the plastic beer bottle and is in the best interest of the beer industry. For, if the bottle jeopardizes recycling, it may not be reasonable to expect this new package to gain acceptance without engendering a strong reaction from the public. And that is why it is essential for *economic* recyclability to be included by brewers among the major criteria for selection of a new plastic package.

The goal of the Plastic Redesign Project is to find win/win solutions for packagers and recyclers. It seeks to do this by working with package designers to help them apply the same ingenuity now focused on front-end performance to the kinds of designs that simplify back-end processing.

Experience demonstrates that this can be done at competitive prices, and, thus, there is no reason for package innovation to erode the current fragile economics of plastics recycling or subtract from the high value inherent in clean resin regrind. At the same time, the Project is educating recyclers that, if designers are properly encouraged to consider these so-called "external costs" that recycling programs bear, packaging innovation can work to the advantage of both those on the front and back end of the product cycle.

This WORKING PAPER is to briefly summarize the issues for recyclers surrounding beer in plastic bottles. At this point in time, since almost all of the key tests from which supportable conclusions can be drawn have not yet been completed, it is only possible to outline the issues and considerations. Reliable conclusions await the outcome of those tests, and will be reported on in an Addendum to this WORKING PAPER. With the ingenuity of the design industry, we fully anticipate that an economically recyclable plastic beer bottle will be developed. What remains to be seen is whether all brewers can be convinced to utilize a recyclable design, instead of problematic packages.

One further note before proceeding: This paper focuses on Miller only because it is the one brewer presently on the market with a plastic beer bottle. The intent, however, is solely to use this example to illustrate in concrete terms the problems that ill-considered designs can create at the back end of a package's life cycle — not to stigmatize in any way any one firm. As far as the Project is concerned, this can be an object learning experience for all of us without any pejorative connotation intended. We look forward to constructive and positive relations with all of the brewers considering a plastic bottle for their product.

The Problems

Polyethylene terephthalate (PET) has been the resin of choice for carbonated soft drinks since soda shifted to plastic in the 1970's, because PET provides greater barrier protection against carbonation leakage than high density polyethylene (HDPE), the other dominant bottle resin. However, because of the different ratio of gas to volume and greater concerns over oxygen penetration, beer makes greater demands for better barrier protection than PET, by itself can provide. Generally, beer requires a four month shelf life.

Thus, PET bottles must be modified, typically by the addition of some barrier material, in order to increase PET's barrier characteristics and provide adequate shelf life for beer.

This barrier material may be of substantial concern to recyclers because, to be sold into high value added markets, the recycled PET must be almost entirely free of contamination. If not readily removed during processing by recyclers, the materials used to enhance barrier performance will remain behind degrading the PET regrind to the point where high end paying markets would be excluded.

In addition to the modifications which provide greater barrier performance, other package components for the cap, label and coloration, if not carefully selected to reflect the lessons learned for the recyclability of soft drink bottles, may also create problems for recyclers. New pigments can require additional sortation and new markets, and some caps and labels may be difficult to remove from the bottle.

Alternative Barrier Designs

There are now three general types of technologies under consideration for the barrier properties of the package (with the related issues of amber tinting and cap and label material discussed separately later). There may be other suppliers and technologies that will be added as they become known to us. We regret any inadvertent omission.

â **NEW RESIN.** Polyethylene naphthalate (PEN) copolymers (i.e. PEN, which has greater barrier qualities than PET alone, blended with PET at a ratio of 10%-25%). Shell Chemical, Eastman Chemical and Amoco are three of the leading vendors for this technology. However, because of the present high cost of the PEN resin that is at least four times the cost of PET, and the problem that PEN is having winning FDA approval (because the agency is concerned about recycling impacts), many observers no longer consider it a likely candidate for widespread commercial beer applications, although the PEN industry believes otherwise.

The three technologies to provide adequate shelf life for beer in a plastic bottle are —

! PEN copolymers

! Multi-layer bottles

! Barrier coatings

ã **MULTILAYER.** A co-injected three or five layer PET bottle in which thin non-PET barrier layers, generally consisting of either the thermoplastics ethylene vinyl alcohol (EVOH) or nylon, are interleaved between the PET layers. American National Can has a five layer version with EVOH as the barrier material, and Continental PET Technologies, which designed the Miller bottle, has five layers with polyamide, a nylon, as the barrier. Schmalbach-Lubeca has a three layer bottle with a nylon as the barrier, and it is being used by Bass Brewers in Europe.

ä **COATINGS.** Gas barrier coatings that are applied to the surface of the bottle. PPG has a coating with the trade name Bairocade(tm) made of epoxyamine, a thermoset resin that is sprayed onto the outside of the bottle about 6 microns thick. Kiren Brewery (Japan) is expected to introduce a "plasma-enhanced chemical vapor deposition" which applies a transparent layer of carbon to the inside of the bottle. Amcor's Container Packaging has announced it will release details of its barrier coating at Nova-Pack on February 1, 1999. Amcor reports that its coating will be used by Australia's Carlton & United Breweries.

Various representations have been made for each barrier as to its impact on recycling, but the tests either have not been made generally available for independent validation or have not been completed at this time. Here is the substance of the issues that are, at present, not conclusively resolved:

Impact of Barriers on Recycling

â **PEN COPOLYMERS**. PEN is not compatible with PET in more than trace amounts. The PEN industry has worked with an autosort manufacturer, MSS, to develop an autodetection separation system designed to remove PEN blended bottles. The efficacy of the this new system (i.e. how many false negatives/positives, which in turn determines how many passes through the system will be required) has not been disclosed, nor has any underlying cost data. We estimate that the cost of closely related PVC autodetection, recognizing the need for multiple passes or slow throughputs and the loss of incorrectly rejected PET, is in excess of six cents per pound of incoming material. Presumably, the costs for PEN detection will not be dramatically different. In addition, no one has specified whether there would be any market for the blended PEN/PET resin that is separated. That is to say, the net effect of handling PET bottles that includes PEN blended beer containers could be a loss of 6 cents per pound of PET (or far more per PEN bottle), without any offsetting gains. Furthermore, in the absence of a market for PET/PEN blended resin, the plastic beer bottles would not be recycled and would have to be landfilled or incinerated after having incurred the expense of separate collection and processing.

ã **MULTILAYER**. The non-PET EVOH or nylon layers are not compatible with PET in more than trace amounts. At present, there is no discussion that autoseparation for these bottles is possible. Rather, recyclability will turn on how much of the barrier remains behind as a potential contaminant of the PET after normal processing. The magnitude of any problem will be a function of:

- The degree of incompatibility created by the particular type of non-PET polymer barrier material;
- The proportion on the barrier material that remains in the PET stream after the normal aspiration and floatation that are part of PET reclamation facilities; and
- The proportion of such multilayer bottles in the PET stream.

The following table shows the number of estimated container units that were in beer and other applications, by container material, in 1997 from which conservative estimates might be generated depending upon one's assumptions.

In terms of the potential market for plastic beer bottles, the data indicates that, on a container unit basis, there are 2½ times as many containers that could be shifted to plastic from glass and aluminum than there are plastic soft drink bottles currently in use. By weight, the potential plastic beer bottle market would be 25% more than the entire PET stream of soft drink and custom bottles currently being recycled.

NUMBER OF CONTAINER UNITS BY MATERIAL AND BY APPLICATION IN 1997
(billions of container units)

	APPLICATIONS		
MATERIAL	**Beer**	**Soft Drink**	**Other**
Glass	19.5	0.9	17.9
Aluminum	34.2	62.6	0
Plastic	0	21.4	10.7

The only major test of a plastic beer bottle in the U.S. is the Continental PET Technologies five layer bottle being deployed by Miller Brewing in six test markets. Continental states that its polyamide barrier material is less than 5% by weight of the bottle. It also indicates that independent laboratory tests by Plastics Forming suggest that 30-40% of the material will be aspirated or floated off during normal processing, leaving about 3% of the barrier material by weight with the PET flake.

As to how much of the PET stream would consist of multilayer bottles, that is very difficult to predict, because it depends upon how much plastic displaces glass and, perhaps, aluminum. However, the impact will need to be evaluated not on the basis of the amount used by Miller in this test or during Miller's rollout, but when this technology is commercialized for beer use forth entire application at which it is aimed. That is to say, it needs to be evaluated as if the entire non-premium grade beer in glass, and perhaps aluminum, market, for example, were to convert to the Continental bottle (see foregoing table). In turn, Continental also indicates that, as a thermoplastic, the residual will be miscible in the PET and the 3% polyamide fraction.

Recognizing that laboratory tests are not adequate for final real-world conclusions, Continental and Miller have correctly asked two commercial reclaimers, Envipco and Wellman, to do commercial tests in order to confirm the laboratory tests. Those results have not yet been performed at this time as the reclaimers are accumulating sufficient quantities to process through their high volume wash systems. In order to evaluate economic recyclability, when these tests are completed, data will need to be compiled as to how much of the barrier material is removed from the incoming PET beer bottles, and on the parameters related to the bottle flake's marketability into sheet and bottle markets (e.g. intrinsic viscosity and Hunter L and b values for clarity), as well as fiber markets.

NOTE: *Although much of the recycled PET is currently recycled into fiber, not sheet and bottle markets, this is a low end application that pays approximately 4¢ to 6¢ per pound less than bottle and sheet.*

- **BARRIER COATING.** The barrier coatings are also incompatible with PET in more than trace amounts. PPG states that it has formulated its coating to provide four month shelf life at comparable costs to multilayer bottles and are to be removable in the reclaimers' existing washing systems. Constar is presently in the process of independently testing the PPG coated bottles, but that evaluation is going slowly due to the problem providing a sufficient number of bottles to run commercial scale tests when the only bottles being produced are in test batch quantities. Information is not yet available on what testing is being performed by Kiren Brewery and Amcor.

NOTE: *Approximately 75-80% of beer is heat-pasteurized and the bottles are filled while the product is hot. The current plastic beer bottles are only able to fill with cold-filtered beers. When hot fill varieties are rolled out it is not expected that this will change the overall situation vis-a-vis recycling. Most recently, Shell announced that an advance in its PEN/PET copolymer bottle, with 10% PEN, could be used for heat-pasteurized beer at a cost, it reports, of 25¢-30¢ more per pound than PET.*

Other Package Concerns

Amber Tint

Most glass bottles for beer are tinted amber and some green. There are already green PET soft drink bottles, but there is presently no amber in the PET stream, except for trace amounts of certain liquor bottles. The chemistry of the amber dye is incompatible with the green dye and strapping markets, for example, indicate that the two colors cannot be mixed chemically.

This suggests that an additional color sort to separate amber tinted PET bottles will be required in addition to the current clean/green split in the PET stream. Each additional sort, when done manually at a material recovery facility will cost approximately 2-4 cents per pound. In the future, Continental PET Technologies has indicated informally that intends to commit to buy back its amber beer bottles which it will use as recyclate in the inner core of its bottle matrix. At this time, Continental has not yet projected how much it will pay for the amber bottles, nor who will pay shipping.

Other Concerns —
! Amber Tint
! Aluminum Caps
! Metalized Labels

The price that will be paid for the amber bottles is important because that price will also need to compensate recyclers for the additional separation costs incurred when amber is sorted from green bottles. Continental reports that it has had preliminary conversations with Envipco which, it says, suggests to them that the cost of autosorting the amber from the green at the intermediate processor — in lieu of an additional manual sort at MRFs— will be minor. As precise cost figures become available, the economics of adding amber PET recycling will need to be evaluated. To perform this calculation, a projection of the number of PET beer bottles will also need to be made (see chart above).

The only technology that might avoid all of these complications — under the assumption that the beer industry will be reluctant to abandon the amber color association with their product — is the barrier coating. (Of course, if the marketing color association can be avoided, any needed UV protection can be provided with additives that do not require tinting.) PPG has developed an amber tint within its barrier coating that, they assert, washes off with the coating without increasing water treatment costs. Another option might include a full body label to provide coloration in lieu of tinting the body, although full body wraps are expensive.

Caps

Historically, beer sold in screw top glass bottles has used aluminum caps, and Miller has continued the same cap on its plastic bottle. This repeats the situation that previously occurred when the early generation PET soft drinks bottles were launched using aluminum caps like their glass bottle counterparts. Recyclers' attempts to add equipment to mechanically separate the aluminum wound up being totally impractical. Eddy current and electrodynamic separators were hooked up in series, but they were very expensive and required the plastic stream to be dried before the equipment would work properly. Also, because the ground caps curled up around the EVA liner during the wash process, the presence of that piece of plastic confounded the machines' detection capability. In that case, a polypropylene (PP) cap was developed as a replacement, with a PVC, and later, when PVC became a problem, an EVOH, liner to provide a seal against the loss of carbonation. While the PP cap was initially slightly more expensive than the aluminum one, as volume sales of plastic caps mounted, the price came down to be competitive with aluminum.

Such a PP cap design will not be immediately adaptable to beer because the limiting condition for beer is oxygen ingress, not carbonation egress as in soft drinks, although the Karlsberg tests are said to have used a polypropylene screw-on cap. In any event, it is generally accepted that this problem can be engineered around, and in the United States Owens-Brockway, and no doubt others, are presently working on a plastic beer cap that will float off in the sink/float tanks used by processors.

NOTE: *An important consideration in the design of such a PP cap for beer is to insure that the new configuration not impair the current recyclability of the PP caps in the PET stream. That is to say, since HDPE base cups have been effectively eliminated on soft drink bottles, all of the plastic material that floats in the sink/float separator used by PET reclaimers is PP since much of the light EVOH cap liners have been previously separated from the cap with air curtains. Almost all of that PP is presently being successfully recycled, and whatever new cap is developed for beer should not jeopardize those systems. Care should be taken to insure that the liner material for beer will behave similarly.*

Another hurdle that may impede conversion to a more compatible cap is that some of the marketing officials in the beer industry are said to be more concerned creating a "look" for their new plastic bottles that most closely resembles the look of their glass bottles— here meaning an aluminum cap. Miller has indicated that this is the reason why its test currently employs aluminum caps, even though they are aware of the problem it creates for recyclers.

Labels

Another feature sometimes used on glass beer bottles is metalized labels. This creates severe problems for PET recyclers. because metalizing the label gives this material a density greater than 1.0. In the reclaimers' sink/float tanks, materials heavier than water will sink in water with the granulated PET flake, which is also heavier than water, and contaminate the regrind. PP shrink and snap on wraps are available to label PET bottles that do not require hard to remove adhesives and are aspirated and float off in processing.

The Miller plastic beer bottle, like its glass predecessor, uses a aluminized label to maintain the appearance of the glass bottles, even though Miller is aware of the problem this creates for recyclers.

Recommendations

In general, Miller's vendor, Continental PET Technologies, is following a reasonable procedure to evaluate the recyclability of its new bottle's barrier material by first running laboratory tests, and then moving onto commercial testing for recyclability. It is also evaluating autosorting color systems and possible internal markets for the amber tinted material. If the analysis of the resulting flake is appropriate to determine suitability for high-end bottle and sheet applications, and if all the economic costs of separating amber are specified, then the critical element of economic, as well as technical, recyclability can be judged. What has seemed less evident, on the other hand, is similar attention by Miller to the recyclability of the label and cap.

Most important, because Miller has not yet stated that economic recyclability will be a key criteria for selection, it also would be reassuring to the recycling industry for Miller to formally commit to not rollout a plastic beer bottle unless it first demonstrates in these or subsequent commercial tests that, if the bottle design is utilized by the entire application at which it is aimed (e.g. the entire non-premium grade beer in glass and aluminum market) —

- â The bottle, including its cap, label and color components, could be recycled without increasing the current cost to recycle PET plastic bottles;
- ã The resultant recycled PET flake stream meets the performance specifications for high-end paying sheet and bottle markets.

For this evaluation to be validated, these tests should be made publicly available in their entirety.

NOTE*: Recently suppliers have developed a plastic bottle mold with a champagne base at the bottom of the bottle. If this design is intended to be used by the premium brands, then the assumed rollout in which recyclability is tested needs to also include premium brands as well.*

In addition, where further redesigns can decrease current processing costs, and those designs cost less to implement in the aggregate than the savings they achieve through lower processing costs, they should also be incorporated in the new bottle.

Economic recyclability should be an equally important criteria as consumer acceptance. Since the needs of the packagers and recyclers can both be met, whether it be a modified form of the current Miller plastic beer bottle, or another technology's plastic beer bottle, agreement by brewers to comply with these tests should not preclude the brewers' ability to rollout a plastic container for their product in a reasonable time frame.

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the Plastic Redesign Project

The PLASTIC REDESIGN PROJECT is funded by the US Environmental Protection, with additional financial support from California, New York and Wisconsin. Its goal is to promote designs for plastic bottles that meet product manufacturers performance and appearance specifications for the packages that their product is sold in — but which, at the same time, do not impede cost-efficient recycling of the package after it is discarded by the consumer. To find win/win design solutions for recyclers and packagers, in Phase I the cities of Dallas, Jacksonville, Milwaukee, New York, San Diego and Seattle worked with Avery Dennison, Johnson Control, Owens Illinois, Procter & Gamble, SC Johnson Wax, and St. Jude Polymer to develop 13 consensus recommendations. In Phase II, 32 states' recycling officials are participating in a joint effort to work with product manufacturers to implement the design recommendations. The states are Arizona, California, Colorado, Connecticut, Delaware, Florida, Illinois, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Nevada, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Texas, Vermont, Wisconsin, Wyoming.

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